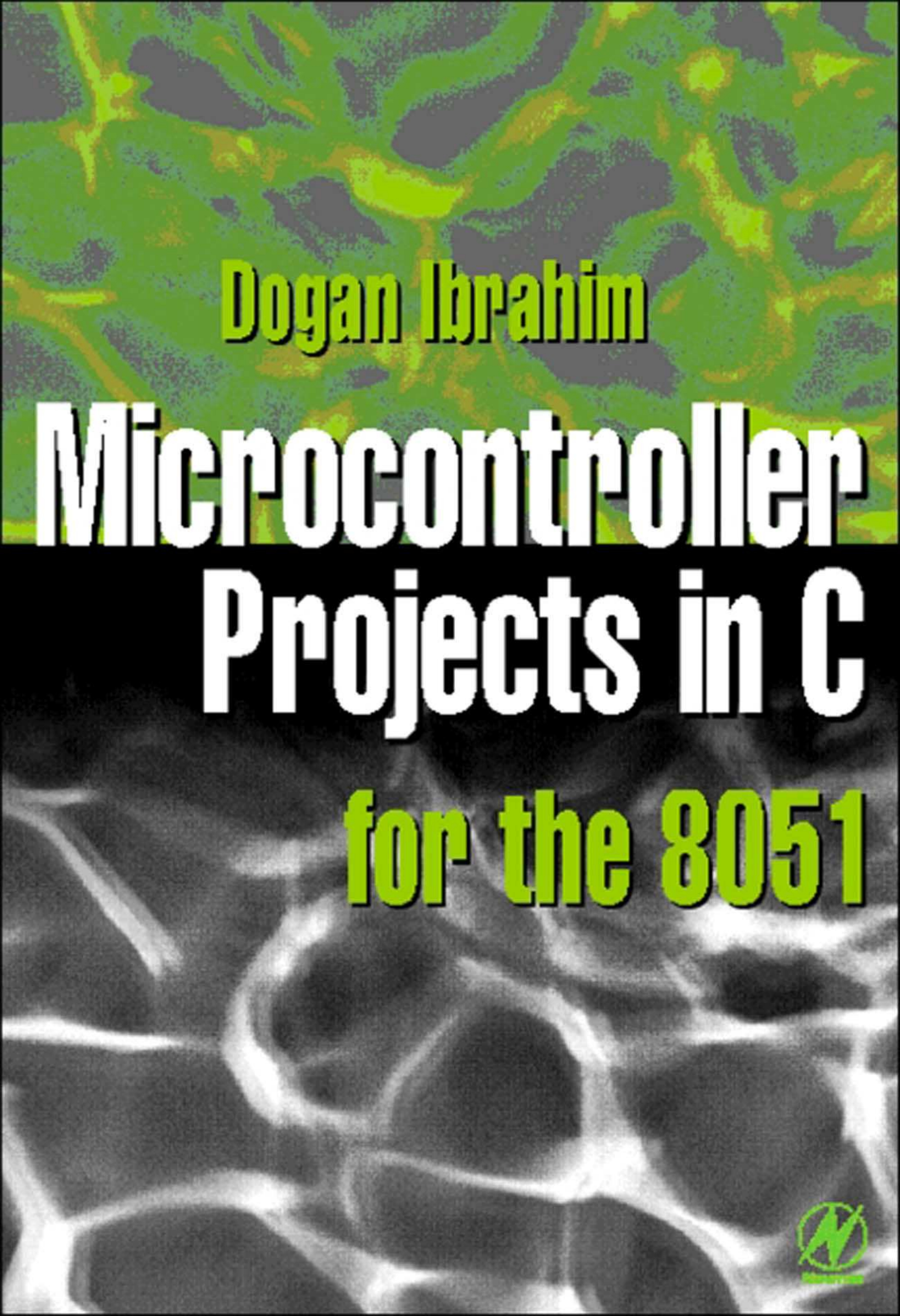

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Contents

Preface

A microcontroller is a single chip microprocessor system which contains data and program memory, serial and parallel I/O, timers, external and internal interrupts, all integrated into a single chip that can be purchased for as little as $2.00. It is estimated that on average, a middle-class household in America has a minimum of 35 microcontrollers in it. About 34% of microcontroller applications are in office automation, such as laser printers, fax machines, intelligent telephones, and so forth. About one-third of microcontrollers are found in consumer electronics goods. Products like CD players, hi-fi equipment, video games, washing machines, cookers and so on fit into this category. The communications market, automotive market, and the military share the rest of the application areas.

Microcontrollers have traditionally been programmed using the assembly language of the target microcontroller. Different microcontrollers from different manufacturers have different assembly languages. Assembly language consists of short mnemonic descriptions of the instruction sets. These mnemonics are difficult to remember and the programs developed for one microcontroller cannot be used for other types of microcontrollers. The most common complaint about microcontroller programming is that the assembly language is somewhat difficult to work with, especially during the development of complex projects. The solution to this problem is to use high-level languages. This makes the programming a much simpler task and the programs are usually more readable, portable, and easier to maintain. There are various forms of BASIC and C compilers available for most microcontrollers. BASIC compilers are usually in the form of interpreters and the code produced is usually slow.

Another disadvantage of BASIC is that most BASIC compilers are not structured and this makes the program maintenance a difficult task. In this book we shall be using a fully featured professional C compiler to program our target microcontroller.

This book is about programming the 8051 family of microcontrollers using the C language, and I have chosen the AT89C2051 microcontroller for all the examples. AT89C2051 belongs to the industry standard 8051 family of microcontrollers. AT89C2051 is a 20-pin device which is fully code compatible with its bigger brother 8051. The device contains a serial port, 15 bits parallel I/O, two timer/counters, six interrupt sources, 128 bytes of data RAM, and 2 Kbytes of reprogrammable flash program memory. There are many reasons for choosing the AT89C2051, including its compatibility with the 8051 family and the ease of erasing and reprogramming the device. There is no need to use a UV eraser to erase the program memory. The memory can be erased and then reprogrammed by using a low-cost programmer. Other reasons for using the AT89C2051 are its low cost and small size. All of the examples given herein can run on all members of the 8051 family.

Chapter 1 provides an introduction to the architecture of the 8051 family, with special emphasis on the AT89C2051 microcontroller. Chapter 2 describes the features of the C compiler used throughout the projects in this book. Addresses of some popular web sites are also given in this chapter which contain information on the 8051 family. Chapter 3 provides many light-based projects. The circuit diagrams and the full C code of all the projects are given with full comments and explanations. All the projects have been built and tested on a breadboard. Chapter 4 is based on sound projects and there are working projects from simple buzzer circuits to electronic organ projects. Chapter 5 provides several working temperature-based projects using digital temperature sensors and analogue-to-digital converters. Finally, Chapter 6 describes several RS232-based projects which explain how information can be transferred between a microcontroller and external devices.

Dogan Ibrahim
1999, London

CHAPTER 1

MICROCOMPUTER SYSTEMS

1.1 Introduction

The term microcomputer is used to describe a system that includes a microprocessor, program memory, data memory, and an input/output (I/O). Some microcomputer systems include additional components such as timers, counters, analogue-to-digital converters and so on. Thus, a microcomputer system can be anything from a large computer system having hard disks, floppy disks and printers, to single chip computer systems.

In this book we are going to consider only the type of microcomputers that consist of a single silicon chip. Such microcomputer systems are also called microcontrollers.

1.2 Microcontroller Evolution

First, microcontrollers were developed in the mid-1970s. These were basically calculator-based processors with small ROM program memories, very limited RAM data memories, and a handful of input/output ports.

As silicon technology developed, more powerful, 8-bit microcontrollers were produced. In addition to their improved instruction sets, these microcontrollers included on-chip counter/timers, interrupt facilities, and improved I/O handling. On-chip memory capacity was still small and was not adequate for many applications. One of the most significant developments at this time was the availability of on-chip ultraviolet erasable EPROM memory. This simplified the product development time considerably and, for the first time, also allowed the use of microcontrollers in low-volume applications.

The 8051 family was introduced in the early 1980s by Intel. Since its introduction, the 8051 has been one of the most popular microcontrollers and has been second-sourced by many manufacturers. The 8051 currently has many different versions and some types include on-chip analogue-to-digital converters, a considerably large size of program and data memories,